CHAPTER 2

DRAFTING EQUIPMENT

Drawing is often called the universal language. Drafting is the particular phase of drawing that engineers and designers use to convey and record ideas or information necessary for the construction of structures and machines. There are definite rules of usage to ensure that the same meaning is conveyed at all times and to enable those who learn the rules to interpret what is presented in a drawing. In contrast to pictorial drawings, such as paintings of landscapes and living things, engineering drawings use a graphical language to describe every integral part of an object. As an Engineering Aid, you will specialize in engineering drawings, whereas the Illustrator Draftsman will specialize in pictorial drawings.

In studying this chapter, you will learn that drafting is classified into types, such as technical, illustrative, mechanical, freehand, and engineering drafting. Then you will go on to learn about charts, graphs, drafting guidelines, and a variety of instruments and materials, all of which are designed to help you perform your drafting duties. This chapter also contains many pointers that will help you operate, adjust, and maintain your drafting instruments.

TYPES OF DRAFTING

Generally, drafting is classified according to its purpose or the means by which it is accomplished.

TECHNICAL AND ILLUSTRATIVE DRAFTING

A distinction is often made between technical drafting and illustrative drafting. TECHNICAL DRAFTING presents technical information in a graphic form; for example, a drawing that shows the type and proper placement of structural members in a building. ILLUSTRATIVE DRAFTING presents a pictorial image only; an example is a perspective drawing of a proposed structure. The term *illustrative drafting* is not commonly used in construction drafting.

MECHANICAL AND FREEHAND DRAFTING

MECHANICAL DRAFTING, as distinguished from freehand drafting, is any drawing in which the pencil or pen is guided by mechanical devices, such as compasses, straightedges, and french curves. In FREEHAND DRAFTING the pencil or penis guided solely by the hand of the draftsman. Sketches are the result of freehand drafting. With the exception of lettering, most technical drafting is mechanical drafting in this sense of the term.

In a different sense, the term *mechanical* applies to certain types of industrial or engineering drawings, regardless of whether the drawings are done mechanically or freehand. Some authorities confine the term, used in this sense, to the drawing of machinery details and parts. Others confine it to the drawing of plumbing, heating, air conditioning, and ventilating systems in structures. In the SEABEEs, mechanical drawing means the arrangements of machinery, utility systems, heating, air conditioning, and ventilating systems.

ENGINEERING DRAFTING

As an Engineering Aid, you will be primarily concerned with the following broad types of engineering drafting:

1. Topographic drafting, or drafting done in connection with topographic and civil engineering surveys. It may include drawings not directly related to topographic maps, such as plotted profiles and cross sections.
2. Construction drafting, or drafting of architectural, structural, electrical, and mechanical drawings related to structures.

3. Administrative drafting, or drafting done in support of the administrative and operational functions of your unit, such as technical and display charts, safety and embarkation signs, project completions, and unit readiness graphics.

In performing drafting duties, you will be working from sketches, field notes, or direct instructions from your drafting supervisor.

Engineering Charts and Graphs

Graphic presentation of engineering data means using CHARTS and GRAPHS, rather than numerical tables or word descriptions, to present statistical engineering information. Properly constructed, each form of chart or graph offers a sharp, clear, visual statement about a particular aspect or series of related facts. The visual statement either emphasizes the numerical value of the facts or shows the way these facts are related, A chart or graph that emphasizes numerical value is called **quantitative;** one that emphasizes relationships is called **qualitative.** The trend of an activity over a period of time, such as the mishaps summary report of a deployed unit rendered over a 6-mo deployment period, is more easily remembered from the shape of a curve describing the trend than from numerical statistics. Successful graphic presentation of engineering data requires as much drafting ability as the graphic representation of engineering objects. Lines must be sharp, opaque, well contrasted, and of uniform weight. Letters and figures are normally executed with the standard lettering set according to accepted conventions.

Charts and graphs are classified as **technical** or **display** charts.

TECHNICAL ENGINEERING CHARTS usually are based on a series of measurements of laboratory experiments or work activities. Such measurements examine the quantitative relationship between a set of two factors or variables. Of the two variables, one has either a controlled or regular variation and is called the independent variable. The other is called the dependent variable because its values are related to those of the independent variable. The line connecting plotted points is called a curve, although it may be broken, straight, or curved. The curve demonstrates the relationship between the variables and permits reading approximate values between plotted points.

DISPLAY CHARTS are organized primarily to convey data to nontechnical audiences. The message presents a general picture of a situation, usually comparative. There are many varieties of display charts, including bar charts, status charts, and training aids. In a SEABEE battalion, display charts are frequently used in operations and training departments. When so used, they must conform to minimum standards prescribed by the command.

Any construction job involves quantities of people, materials, and equipment. Efficient operation and completion of the job result from planning, organization, and supervision. Graphic presentation of data is important. Statistics based on the results of past jobs with similar working conditions provide a basis for predicting the amount of time that a proposed job will take. These statistics offer the best possibilities for study when presented graphically, usually in the form of a curve. The prediction of expected achievement usually is presented as a bar chart and is called a time-and-work schedule, When the scheduled work progress is compared with the actual progress (work in place), the chart is called a progress chart.

Drafting Guidelines

As stated earlier, there are definite guidelines in drafting. These guidelines provide uniform interpretation of all engineering drawings. Any drawing prepared by or for the Navy must be prepared following the latest military standard (MIL-STD), Department of Defense Standard (DOD-STD), and applicable NAVFACENGCOM design manuals. For subjects not covered by these references, you might refer to civilian publications, such as the *Architectural Graphic Standards.* Or, you may devise your own symbols, provided that any nonstandard features in your drawing are supported with adequate explanation by notes or by legend.

Many drawings continue in use for years. Therefore, you will have occasion to work with drawings that contain obsolete symbols. Look for a legend on the drawings; it should help you in reading symbols with which you are not familiar. If there is no legend, study the drawing carefully and you should be able to interpret the meaning of unfamiliar symbols and abbreviations.

DoD drawing standards, which are constantly being updated, are published by the Assistant Secretary of Defense (Supply and Logistics), Office of Standardization. Any Navy activity can obtain copies of these standards by writing to the following: Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120. All requests should state the title and identifying number and should be submitted on DD Form 1425. To ensure that you have the latest edition of a standard, check the *Department of Defense Index of Specifications and Standards,* which is issued 31 July of each year. Also check the supplements to the Index.

Current editions of the following military standards should be available to the EA:

MIL-HDBK-1006/1	*Policy and Procedures for Project Drawings and Specifications Preparation*
MIL-STD-12D	*Abbreviations for Use on Drawings and in Technical Type Publications*
MIL-STD-14A	*Architectural Symbols*
MIL-STD-17B	*Mechanical Symbols*
MIL-STD-18	*Structural Symbols*
DOD-STD-100C	*Engineering Drawing Practices*

In addition, the following civilian industry standards should be on hand in the drafting room:

ANSI Y14.1	*Drawing Sheet Size and Format*
ANSI Y14.2	*Line Conventions and Lettering*
ANSI Y14.3	*Multi and Sectional View Drawings*
ANSI Y14.5-82	*Dimensioning and Tolerancing for Engineering Drawings*
AWS A3.0-85	*Welding Terms and Definitions Standards*
ASTM E380	*Standard for Metric Use*

DRAFTING EQUIPMENT

To be a proficient draftsman, you must be familiar with the tools of your trade and the proper techniques of using them. Great care must be given to the proper choice of drafting equipment and accessories. To have a few good pieces of equipment is much better than to have a large stock of undependable and shoddy equipment.

NAVAL MOBILE CONSTRUCTION BATTALION'S STANDARD DRAFTSMAN KIT

As a means of ensuring that every Naval Mobile Construction Battalion's (NMCB's) drafting section is properly outfitted with adequate drafting equipment and accessories, standard draftsman kits are provided in each NMCB's allowance. The drafting equipment and supplies contained in the draftsman kit #0011 are listed in the NMCB's TABLE OF ALLOWANCE (Assembly 80011). For this reason, no attempt will be made here to list all equipment and supplies currently carried in the standard draftsman kit. One complete NMCB's draftsman kit is designed to be used by three draftsmen. Normally, two complete draftsman kits will be carried in a battalion allowance, available for checkout to the drafting section supervisor or engineering chief. It is the responsibility of each crew leader to make sure that the kits assigned to him are complete. The kits are continuously reviewed and updated according to current battalion requirements.

Most of the consumable items contained in the kit, such as pencils, pencil leads, lead holders, masking tape, and ink, are stocked in the battalion supply department for kit replenishment. Additional drafting equipment and supplies, such as pointers and dust brushes, are also stocked in most battalion drafting rooms to supplement the drafting kits.

To avoid losing any equipment and supplies not included in the draftsman kit, personnel should not pack them with the kit when the kit is turned in to the supply department at the end of a deployment or homeport period.

The following sections will acquaint you with general drafting equipment and supplies, with emphasis being placed on items used by SEABEE draftsmen.

DRAFTING MEDIA

Materials used to draw on are referred to as DRAFTING MEDIA. Generally there are three types: paper, cloth, and film. For all practical purposes, you, as a SEABEE draftsman, will use tracing paper, profile paper, plan/profile paper, and cross-section paper. Although it is not found in the draftsman kit, illustration board is used for preparing signs and charts. Tracing cloth and film are rarely used by SEABEE draftsmen, and hence will not be described here.

TRACING PAPER (also called TRACING VELLUM) is a high-grade white (or slightly tinted) transparent paper that takes pencil well, and from which pencil lines can be easily erased. Also, reproductions can be made directly from pencil drawings on tracing paper; however, for better results in reproduction, a pencil drawing on tracing paper is usually inked over.

PROFILE, PLAN/PROFILE, and CROSS-SECTION PAPER are referred to as GRIDDED MEDIA. Each type of gridded media is designed for a specific purpose. Most gridded media used by EAs are suitable for reproduction.

PROFILE PAPER is normally available in two grid patterns: 4 by 20 lines (4 lines vertical and 20 lines horizontal) per inch and 4 by 30 lines per inch with the vertical lines accented every 10th line. Horizontal lines on the 4 by 20 are accented medium-weight every 5th line and heavyweight every 50th line. Horizontal lines on the 4 by 30 have heavyweight accent lines every 25th line. Profile paper is generally used for road design profiles.

PLAN/PROFILE PAPER has rulings and grid accents similar to those of 4 by 20 and 4 by 30 profile paper, except that the grid patterns occupy only the lower half of the paper. The upper half is plain paper, used to draw the plan view in relation to the profile or to add explanatory notes to the profile. Plan/profile paper is also used for road design.

CROSS-SECTION PAPER, sometimes referred to as graph paper, is available in a variety of grid patterns. Generally, graph paper used by the EA has a grid scale of 10 by 10 lines per square inch. It is used for drawing road cross sections, rough design sketching, preparing schedules, plotting graphs, and many other uses.

Most drafting media are available in three styles: plain sheets or rolls, preprinted sheets with borders and title blocks, and sheets with non-reproducible grids. For further information on the many varieties of drafting media available, refer to suppliers' catalogs, such as those published by Keuffel & Esser Co. and Eugene Dietzgen Co.

ILLUSTRATION BOARD is a drawing paper with a high rag content mounted on cardboard backing. The type normally found in a SEABEE drafting section has a smooth white drawing surface that takes ink readily. Normally, the board is 30 in. by 40 in. and comes in 50-sheet packages. Illustration board is used by the EA for making signs and for large unmounted charts and for mounting maps, photos, and drawings that require a strong backing. A thinner board, called BRISTOL BOARD, is also used for making small signs and charts. The thickness of bristol board is about the same thickness as an ordinary index card. Unlike illustration board, bristol board has two white smooth sides that take ink very well. Bristol board is less expensive than illustration board and is easily cut, to size with a paper trimmer. It is available in many sizes; the most popular size is 20 in. by 30 in. in 50- or 100-sheet packages.

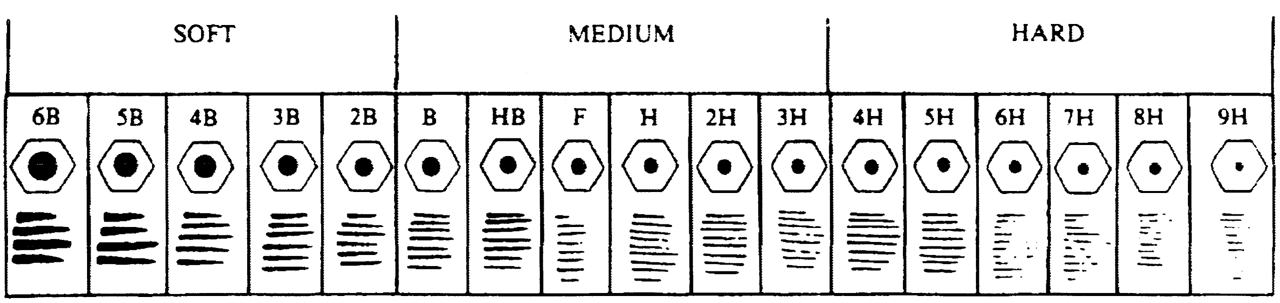

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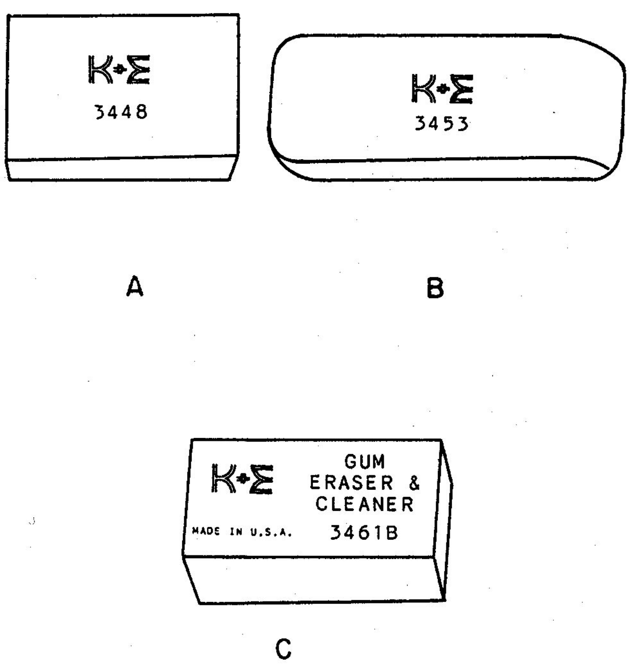
Figure 2-1.—Grades of drafting pencils.

DRAFTING PENCILS

Two types of pencils are used in drafting: wooden and mechanical. The latter is actually a lead holder and may be used with leads of different hardness or softness.

Drafting pencils are graded according to the relative hardness of their graphite lead. A pencil that is considered soft is designated by the letter *B*. On the other hand, a hard pencil is designated by the letter *H*. Figure 2-1 shows 17 common grades of drafting pencils from 6B (the softest and the one that produces the thickest line) to 9H (the hardest and one that produces a thin, gray line).

You will notice that the diameters of the lead vary. This feature adds strength to the softer grades. As a result, softer grades are thicker and produce broader lines, while harder grades are smaller and produce thinner lines. Unfortunately, manufacturers of pencils have not established uniformity in grades. Hence, a 3H may vary in hardness from company to company. With experience and preference, you may select the trade name and grade of pencil that suits your needs. Selection of drafting pencils will be covered in chapter 3.



Courtesy of Keuffel & Esser Company, Rockaway, NJ

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Figure 2-2.-Types of erasers.

ERASERS AND ERASING ACCESSORIES

You must be very careful in selecting an eraser that will remove pencil or ink lines without damaging the surface of the drawing sheet.

A vinyl eraser (fig. 2-2, view A) is ideal for erasing lines drawn on tracing cloth and films. An ordinary double-beveled pencil eraser generally comes in red or in pink color (sometimes called a PINK PEARL). A harder eraser (sometimes called a RUBY RED) (fig. 2-2, view B) is designed for erasing lines in ink. The ART GUM eraser (fig. 2-2, view C), made of soft pliable gum, will not mar or scratch. It is ideally suited for removing pencil or finger marks and smudges.

You can also use a kneaded eraser—the type used by artists. It is a rubber dough, kneadable in your hand, and has the advantage of leaving very little refuse on the drawing sheet.

The so-called STEEL ERASER, shown in figure 2-3, is, of course, actually a scraper. It is used principally for scraping off erroneous ink lines, especially from tracing cloth. The figure shows a short-bladed steel eraser; long-bladed steel erasers are also available. A steel eraser is not generally recommended for use by beginners because it has a tendency to damage the surface of the drawing sheet.

Figure 2-4 shows an ELECTRIC ERASER. The control switch is directly under the fingertip;

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Figure 2-3.-Steel eraser.

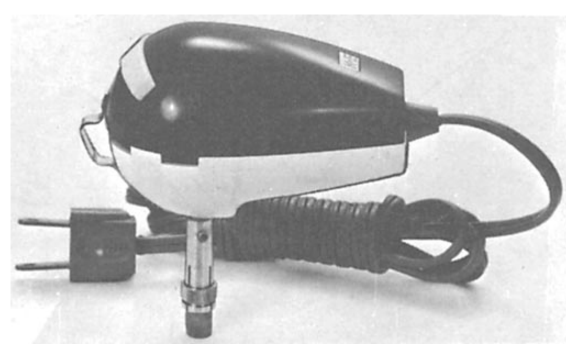

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Figure 2-4.-Electric eraser.

the body of the machine fits comfortably in the palm of the hand, and the rotating eraser can be directed as accurately as a pencil point. Refills for either ink or pencil erasing are available.

CAUTION: Do not hold the electric eraser steady in one spot, or you may easily wear a hole or damage the surface of the material being erased.

When there are many lines close together and only one needs to be removed or changed, the desired lines may be protected by an erasing shield, as shown in figure 2-5.

Finely pulverized gum eraser particles are available in squeeze bottles or in DRY CLEAN PADS for keeping a drawing clean while you work on it. If a drawing or tracing is sprinkled occasionally with gum eraser particles, triangles, T squares, scales, french curves, and the like, not only tend to stay clean themselves, but also tend to clean the drawing or tracing as they are moved over the surface.

Before a drawing is inked, it is usually prepared by sprinkling on POUNCE (a very fine bone dust) and then rubbing in the pounce with a felt pad on the container. Pounce helps to prevent a freshly inked line from spreading. A draftsman's DUST BRUSH should be used for brushing dust and erasure particles off a drawing.

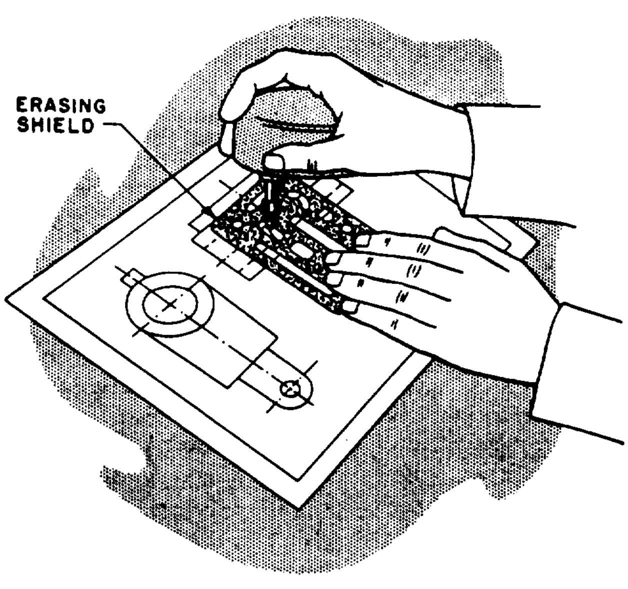

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Figure 2-5.-Use of an erasing shield.

DRAFTING TABLES WITH BOARDS

Most EA shops are furnished with standard drafting tables with drafting boards, as shown in figure 2-6. The majority of this furniture is easily adjustable to the users' needs. The height of the table should be such that if you desire to work in a standing position, you can do so without stooping or holding your arms in a raised position. Hinged attachments for the drafting board are provided to adjust the incline so that your line of sight will be approximately perpendicular to the drafting surface. Your drafting stool should be high enough in relation to the table for you to see the whole drafting board but not so high that you are uncomfortably seated.

The drafting boards contained in the draftsman kit are constructed of joined strips of softwood, usually clear white pine or basswood. They are equipped with hinged attachments for securing the board to a table or fabricated base. If suitable bases are not available, table bases may be constructed at the unit carpenter shop.

You should consider only the left-hand vertical edge as a working edge for the T square if you are right-handed (the right-hand edge if you are left-handed). The T square should never be used with the head set against the upper or lower edge of the board, as the drafting board may not be perfectly square.

The drafting board should be covered. A variety of good drafting board cover material is available. Available cover materials are cellulose acetate-coated paper, vinyl, and mylar film. The vinyl drafting board covers have the added advantage of being able to close up small holes or cuts, such as those made by drafting compasses or dividers. In general, these covers protect the drafting board surface by preventing the drafting pencil from following the wood grain, by reducing lighting glare, and by providing an excellent drafting surface.

Since you will be constantly using your eyes, it is important that your working area be well lighted. Natural light is best, if available and ample, although in the majority of cases acceptable natural light will be the exception rather than the rule. Drafting rooms are usually lighted with overhead fluorescent fixtures. Ordinarily, these fixtures are inadequate in quality and intensity of light. Adjustable lamps will improve the lighting conditions. The most popular type of adjustable lamp is the floating-arm fluorescent fixture that clamps onto the drafting

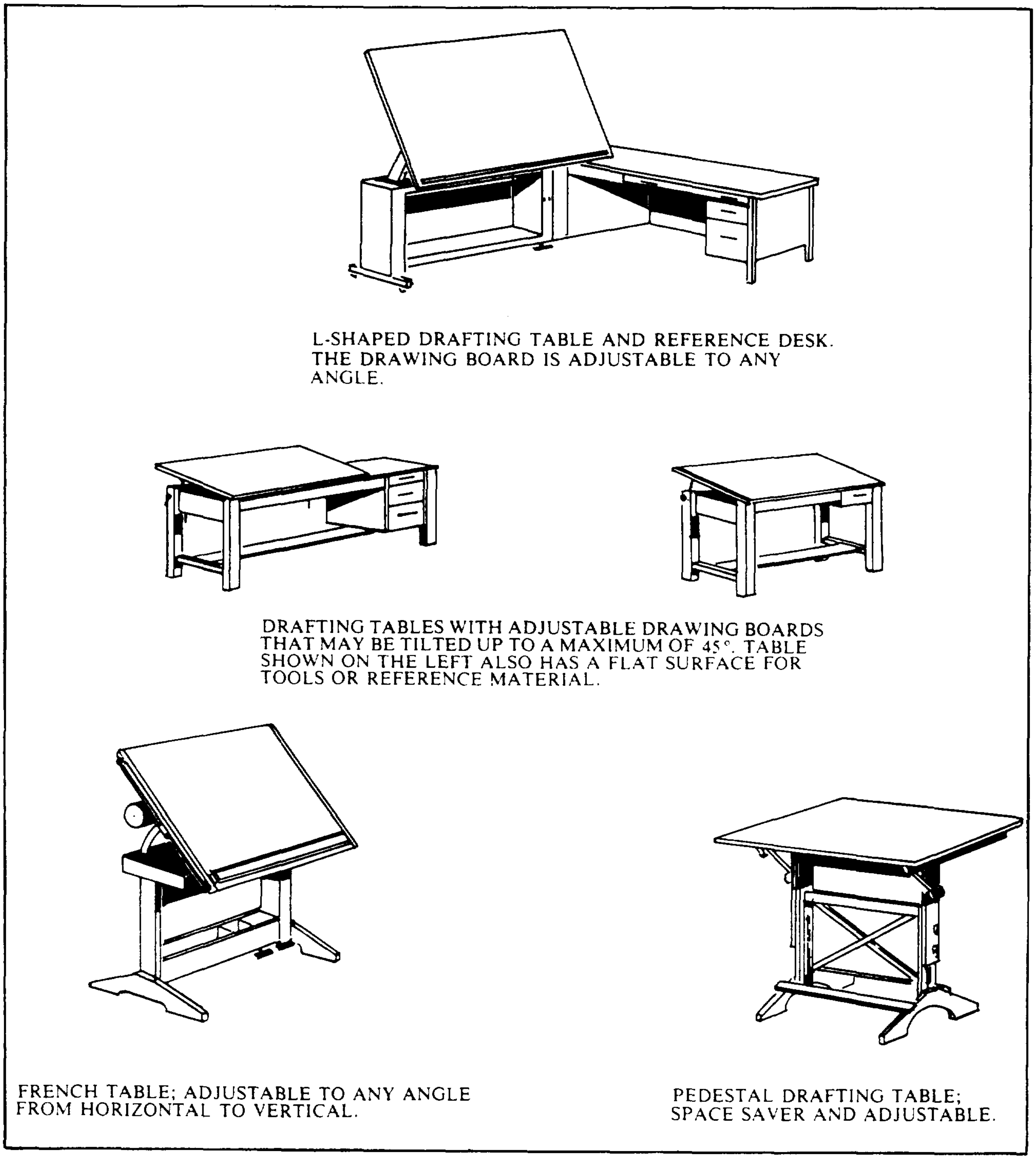

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Figure 2-6.-Drafting tables with boards.

table. Arrange your lighting to come from the front-left, if you are right-handed; from the front-right, if you are left-handed. This minimizes shadows cast by drawing instruments and your hands.

Never place your drafting board so that you will be subject to the glare of direct sunlight. North windows are best for admitting daylight in the Northern Hemisphere. Conservation of vision is of the utmost importance. You must make every possible effort to eliminate eyestrain.

T SQUARES

The T square gets its name from its shape. It consists of a long, straight strip, called the blade, which is mounted at right angles on a short strip, called the head. The head is mounted under the blade so that it will fit against the edge of the drawing board while the blade rests on the surface. T squares vary in size, ranging from 15 in. to 72 in. in length, with the 36-in. length being the most common.

The T square shown in figure 2-7 is typical of the ones used by an EA. The head is made of hardwood and the blade, usually of maple with a natural or mahogany finish. The edges of the blade are normally transparent plastic strips glued into grooves on both edges of the blade, as shown in the cross section in figure 2-7. This allows the edge of the T square to ride above the drawing as the blade is moved up or down the board. This arrangement is a great advantage when you are drawing with ink. Since the tip of the ruling pen does not come in contact with the blade, but is below it, ink cannot be drawn under the blade to blot the drawing.

The T square is used for drawing horizontal lines only. Always draw lines along the upper edge of the blade. The T square also serves as a base for the triangle when vertical and inclined lines are drawn. Some T squares are designed with adjustable heads to allow angular adjustments of the blade.

Handle your T square carefully. If dropped, it may be knocked out of true and become useless. Additionally, to prevent warping, hang the T square by the hole in the end of the blade or lay it on a flat surface so that the blade rests flat.

Before beginning a new job, you should test the top edge of your T square for warp or nicks by drawing a sharp line along the top of the blade.

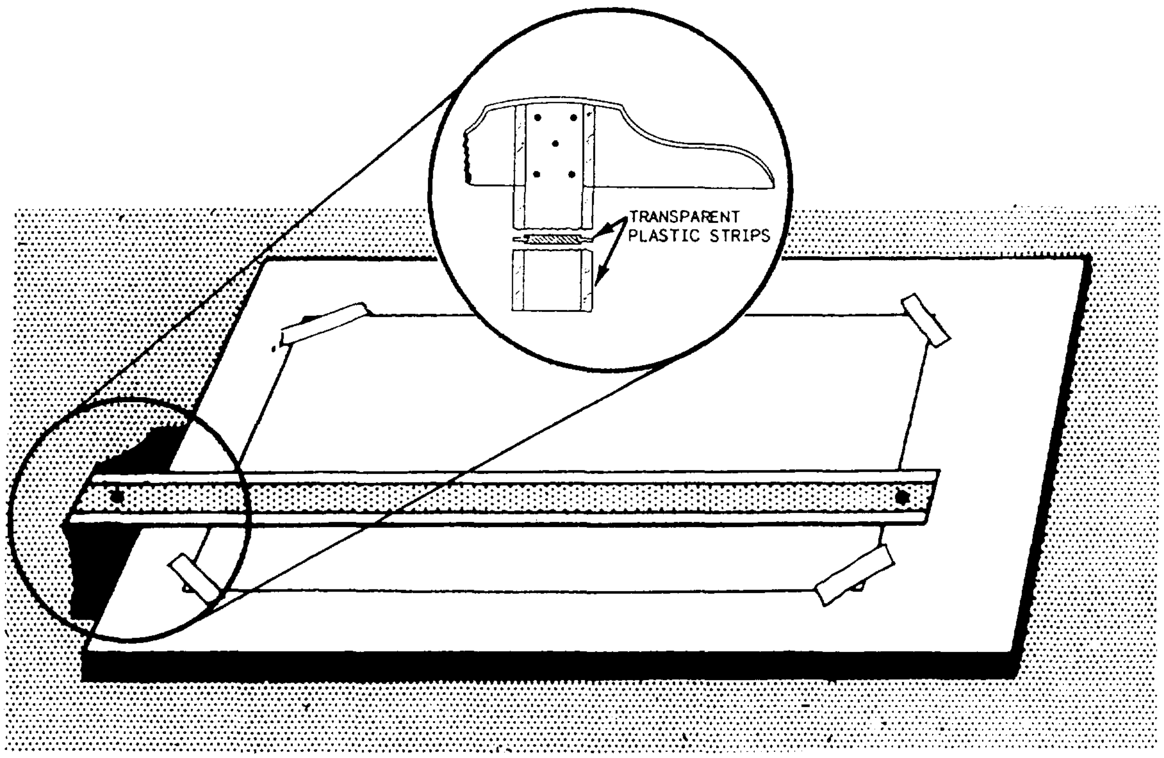

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Figure 2-7.-Drafting board with T square and drafting paper in place.

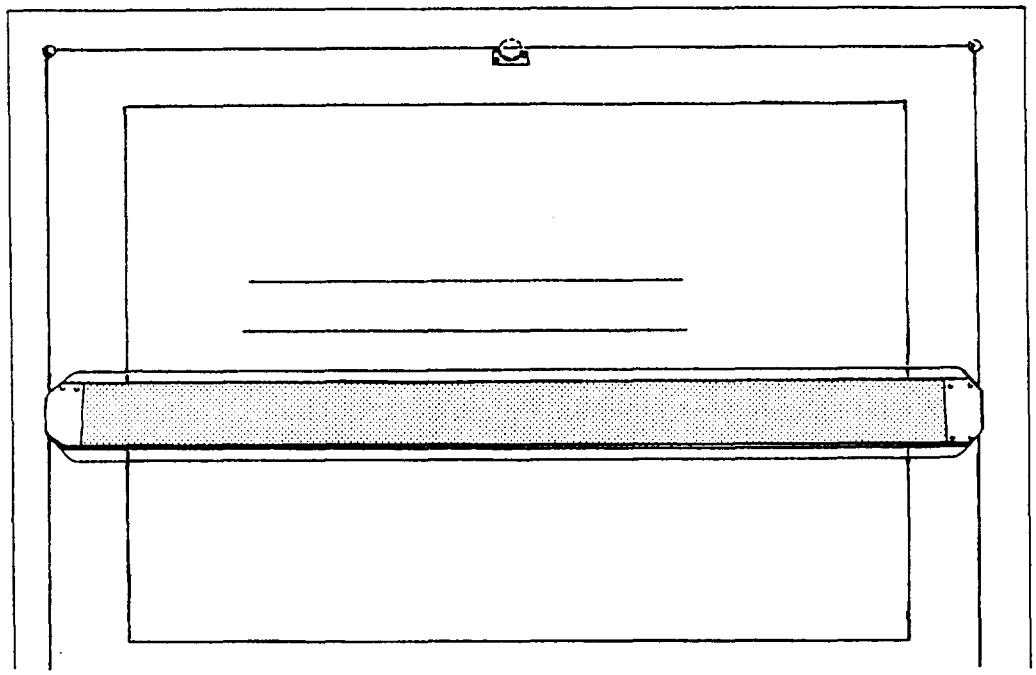

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Figure 2-8.-Parallel straightedge.

Turn the T square over and redraw the line with the same edge. If the blade is warped, the lines will not coincide.

If the blade swings when the head is held firmly against the edge of the drawing board, the blade may be loose where it is joined to the head, or the edge of the T square head may be warped. You can usually tighten a loose blade by adjusting the screws that connect it to the head, but if it is out of square, warped, or in bad condition, you should select a new T square.

PARALLEL STRAIGHTEDGE

Many draftsmen prefer to use a PARALLEL STRAIGHTEDGE (fig. 2-8) rather than a T square. The primary purpose of the parallel straightedge is the same as the T square.

The parallel straightedge is a laminated maple blade with transparent plastic edges similar to those on the T square. The parallel straightedge uses a system of cords and pulleys so that it is supported at both ends by a cord tacked to the drawing board. You can move the straightedge up or down the board with pressure at any point along its length and maintain parallel motion automatically. It comes complete with cord, tacks, cord tension adjuster, and mounting instructions. Some straightedges, like the one shown in figure 2-8, are equipped with a cord lock on one end of the blade. The straightedge is locked into place by turning the cord lock clockwise. This permits use of the straightedge on an inclined board. It also prevents accidental movement when you are inking or using mechanical lettering devices. The advantages of the parallel straightedge become particularly significant when you are working on large drawings. While the T square works well for small work, it becomes unwieldy and inaccurate when you are working on the far right-hand side of large drawings.

STEEL STRAIGHTEDGE

When drawing long, straight lines, you should use a STEEL STRAIGHTEDGE (fig. 2-9) because its heavy weight helps keep the straightedge exactly in position. The steel

Courtesy of Keuffel & Esser Company, Rockaway, NJ

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Figure 2-9.-Steel straightedge.

straightedge is also excellent for trimming blueprints and cutting heavy illustration board.

Steel straightedges are usually made of stainless steel and are available in lengths of 15 in. to 72 in. The one included in the draftsman kit is 42 in. long. Some have a beveled edge, like the one shown in figure 2-9.

TRIANGLES

TRIANGLES are used in combination with the T square or straightedge to draw vertical and inclined lines. They are usually made of transparent plastic, which allows you to see your work underneath the triangles.

Triangles are referred to by the size of their acute angles. Figure 2-10 shows two basic drafting triangles: the 45° (each acute angle measures 45°, and the 30°/60° (one acute angle measures 30°; the other, 60°). The size of a 45° triangle is designated by the length of the sides that form the right angle (the sides are equal). The size of a 30°/60° triangle is designated by the length of the longest side that forms the right angle. Sizes of both types of triangles range from 4 in. through 18 in. in 2-in. increments.

Like all other drafting equipment, triangles must be kept in good condition. If plastic triangles are dropped, their tips may be damaged. Also, triangles may warp so that they do not lie flat on the drawing surface, or the edge may deviate from true straightness. To prevent warping or chipping, you should always lay them flat or hang them up when they are not in use. Since there is seldom enough drawer space available to permit laying triangles flat, it is best to develop the habit of hanging them up. If the tips are bent, use a sharp knife to cut off the damaged part. If the triangle is warped, you may be able to bend it back by hand. If this does not straighten it, leave the triangle lying on a flat surface with weights on it or hold the triangle to the opposite curvature with weights. If the triangle becomes permanently warped so that the drawing edges are curved or the angles are no longer true, throw it away and get another.

To test the straightness of a triangle, place it against the T square and draw a vertical line, as shown in figure 2-11. Then reverse the triangle and draw another line along the same edge. If the triangle is straight, the two lines will coincide; if they don't coincide, the error is half the resulting space.

PROTRACTORS

PROTRACTORS are used for measuring and laying off angles other than those that may be drawn with the triangle or a combination of triangles. Most of the work you will do involving the use of the protractor will involve plotting information obtained from field surveys.

Like the triangle, most protractors are made of transparent plastic. They are available in 6-, 8-, and 10-in. sizes and are either circular or semicircular in shape, as shown in figure 2-12.

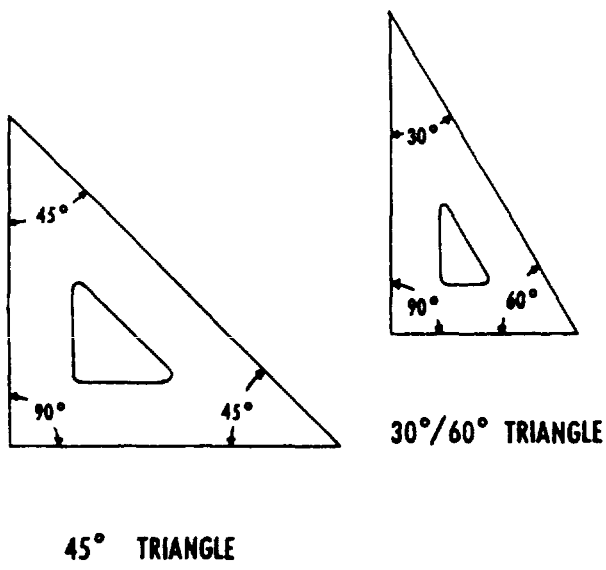

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Figure 2-10.-45° and 30°/60° drafting triangles.

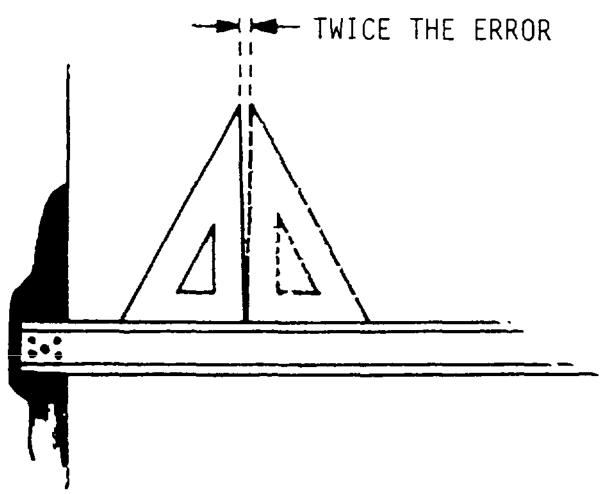

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Figure 2-11.-Testing a triangle for straightness.

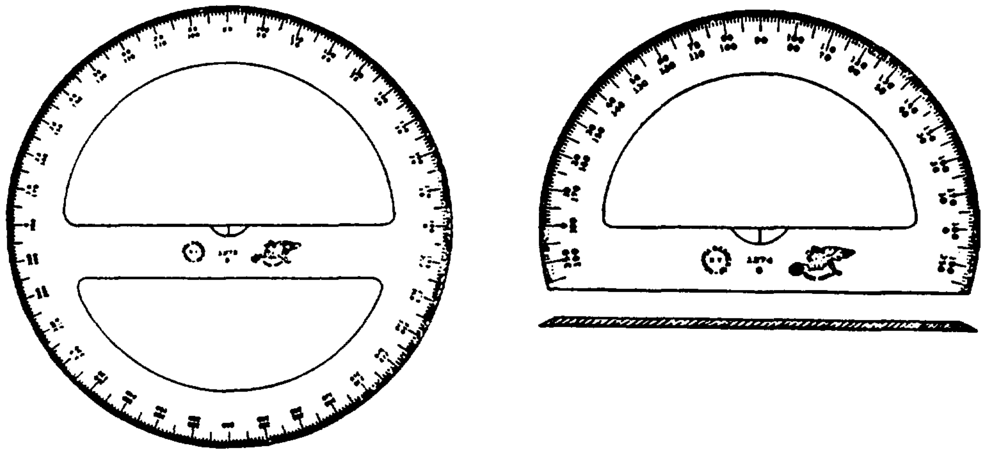

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Figure 2-12.-Types of protractors.

Protractors used by the EA are usually graduated in increments of 1/2°. By careful estimation, angles of 1/4° may be obtained. Protractor numbering arrangement varies. Semicircular protractors are generally labeled from 0° to 180° in both directions. Circular protractors may be labeled from 0° to 360° (both clockwise and counterclockwise), or they may be labeled from 0° to 90° in four quadrants.

Protractors should be stowed and cared for in the same manner as triangles.

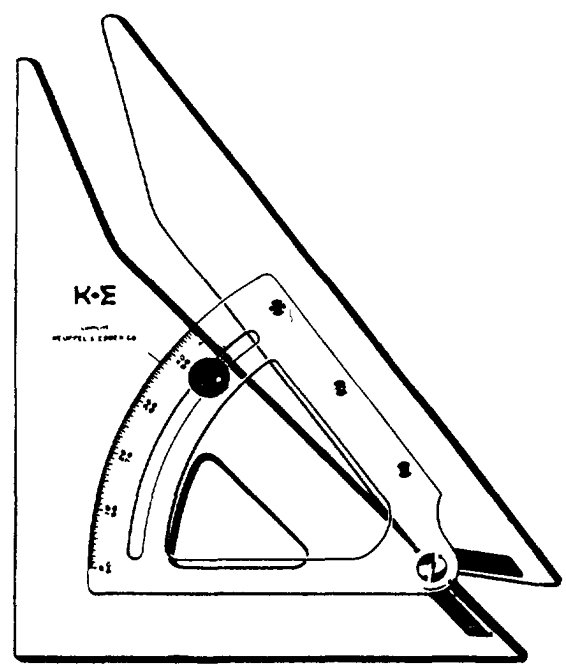
ADJUSTABLE TRIANGLES

The ADJUSTABLE TRIANGLE, shown in figure 2-13, combines the functions of the triangle and the protractor. When it is used as a right triangle, the hypotenuse can be set and locked at any desired angle to one of the bases. The transparent protractor portion is equivalent to a protractor graduated in 1/2° increments. The upper row of numbers indicates angles from 0° to 45° to the longer base; the lower row indicates angles from 45° to 90° to the shorter base. By holding either base against a T square or straightedge, you can measure or draw any angle between 0° and 90°.

The adjustable triangle is especially helpful in drawing building roof pitches. It also allows you to transfer parallel inclined lines by sliding the base along the T square or straightedge.

FRENCH CURVES

Irregular curves (called FRENCH CURVES) are used for drawing smooth curved lines that are not arcs or circles, such as ellipses, parabolas, and spirals. Transparent plastic french curves come in a variety of shapes and sizes.



Courtesy of Keuffel & Esser Company, Rockaway, NJ

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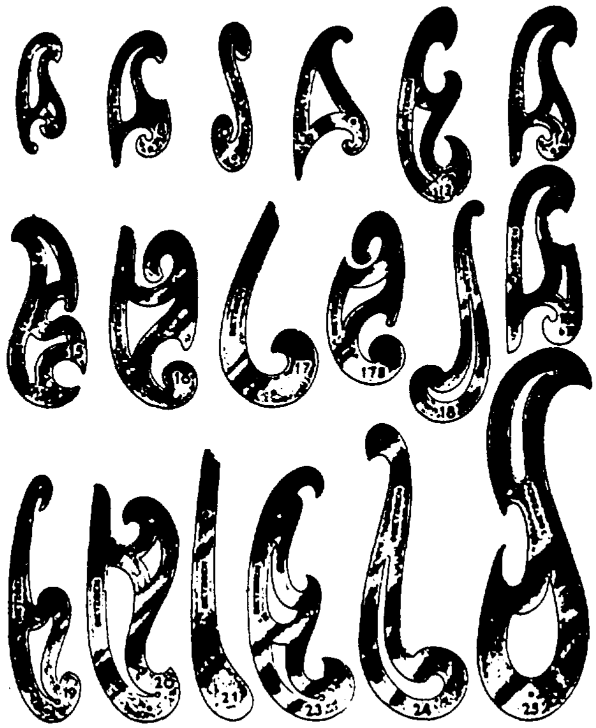
Figure 2-13.-Adjustable triangle.



Courtesy of Dietzgen Corporation

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Figure 2-14.-French curves.

Figure 2-14 shows an assortment of french curves. In such an assortment you can find edge segments that can be fitted to any curved line that you need to draw.

French curves should be cared for and stowed in the same manner as triangles.

DRAWING INSTRUMENT SETS

So far we have discussed only those instruments and materials that you will need for drawing straight lines (with the exception of french curves). Many drawings that you will prepare will require circles and circular arcs. For this purpose, instruments contained in a drawing instrument set are used. Many types of drawing instrument sets are available; however, it is sometimes difficult to judge the quality of drafting instruments by appearance alone. Often their characteristics become evident only after they are used.

The drawing instrument set shown in figure 2-15 is typical of those sets found in the standard draftsman kit. The following sections describe these instruments. Some special-purpose instruments not found in the set will also be described. They may be purchased separately or found in other instrument sets.

Compasses

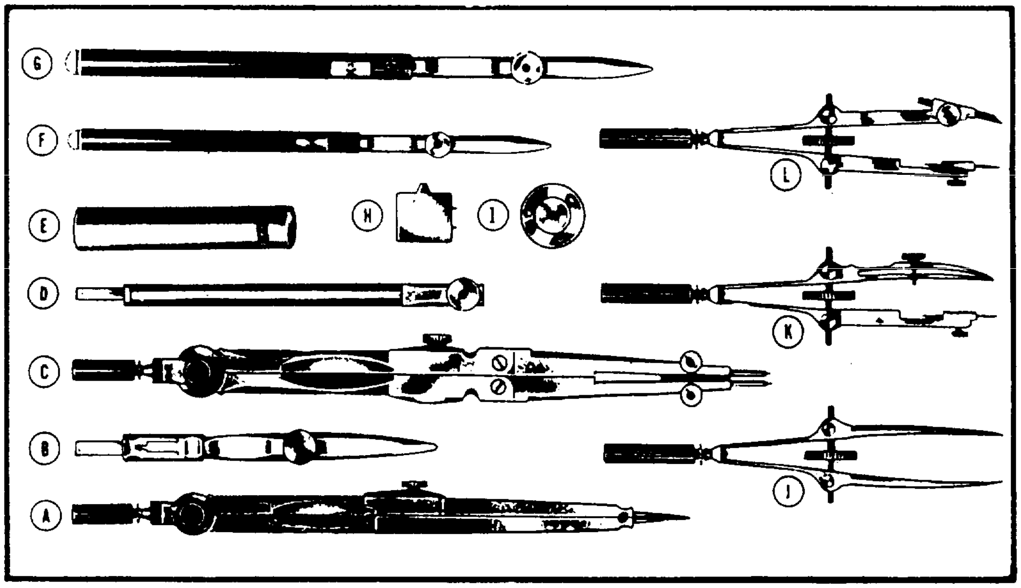
Circles and circular curves of relatively short radius are drawn with COMPASSES. The large **pivot joint compass** (fig. 2-15C) is satisfactory for drawing circles of 1 in. to about 12 in. in diameter without an extension bar. The pivot joint provides enough friction to hold the legs of the compass in a set position. One of the legs is equipped with a setscrew for mounting either a pen (fig. 2- 15B) or a pencil attachment on the compass. There is also an extension bar (fig. 2-15D), which can be inserted to increase the radius of the circle drawn.

The other type of compass found in the drawing instrument set is the **bow compass** (fig. 2-15K and 2- 15L). Many experienced draftsmen prefer the bow compass over the pivot joint compass. The bow compass is much sturdier and is capable of taking the heavy pressure necessary to produce opaque pencil lines without losing the radius setting.

There are two types of bow compasses. The location of the adjustment screw determines the type. The bow pen (fig. 2-15K) and bow pencil (fig. 2-15L) are the **center adjustment type,** whereas the bow instruments shown in figure 2-16 are the **side adjustment type.** Each type comes in two sizes: large and small. Large bow compasses are usually of the center adjustment type, although the side adjustment type is available. The large bow compasses are usually about 6 in. long; the small, approximately 4 in. long. Extension bars are available for large bow compasses. Bow compasses are available as separate instruments, as shown in figures 2-15 and 2-16, or as combination instruments with pen and pencil attachments.

Most compasses have interchangeable needlepoints. The conical or plain needlepoint is used when the compass is used as dividers. The shoulder-end needlepoint is used with pen or pencil attachments.

When many circles are drawn using the same center, the compass needle may tend to bore an oversized hole in the drawing. To prevent these holes, use a device called a **horn center** or **center disk** (fig. 2-151). This disk is placed over the center point. The point of the compass needle is then placed into the hole in its center.



INSTRUMENT SET CONTENTS

- (A) HAIRSPRING DIVIDERS, 6"
- (B) COMPASS PEN ATTACHMENT
- (C) FRICTION HEAD PIVOT JOINT COMPASS, 6 1/2"
- (D) COMPASS EXTENSION BAR
- (E) CONTAINER W/PENCIL LEADS
- (F) RULING PEN, 4 1/2"
- (G) RULING PEN, 5 1/2"
- (H) KEY-SCREWDRIVER COMBINATION
- (I) HORN CENTER, 1/2" DIAMETER
- (J) CENTRAL THUMBSCREW BOW DIVIDERS, 3 3/4"
- (K) CENTRAL THUMBSCREW BOW PEN, 3 3/4"
- (L) CENTRAL THUMBSCREW BOW PENCIL, 3 3/4"

Courtesy of Keuffel & Esser Company, Rockaway, NJ

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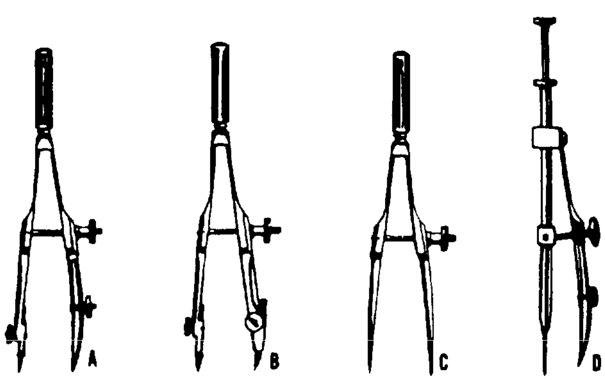
Figure 2-15.-Typical drawing instrument set.



Courtesy of Keuffel & Esser Company, Rockaway, NJ

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Figure 2-16.-Bow instruments: (A) Bow pen; (B) Bow pencil; (C) Bow dividers; (D) Drop bow pen.

Dividers

DIVIDERS are similar to compasses, except that both legs are provided with needlepoints. The instrument set (fig. 2-15) contains two different types and sizes of dividers: **large 6-in. hairspring dividers** (fig. 2-15A) and **small center adjustment bow dividers** (fig. 2- 15J). The large pivot joint compass (fig. 2-15C) may also be used as dividers. As with compasses, dividers are available in large and small sizes, and in pivot joint, center adjustment bow, and side adjustment bow types. Figure 2-16C shows small side adjustment bow dividers. Pivot joint dividers are used for measurements of approximately 1 in. or more. For measurements of less than 1 in., bow dividers should be used. Dividers are used to transfer measurements, to step off a series of equal distances, and to divide lines into a number of equal parts.

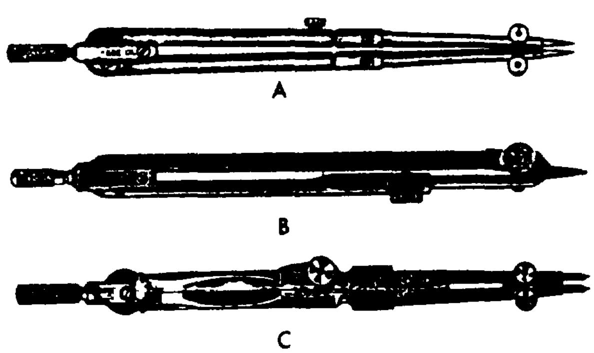
Drop Bow Pen

The DROP BOW PEN (fig. 2-16D) is not one of the standard instruments. However, for some jobs it is essential. It is used to ink small circles with diameters of less than a quarter of an inch. As the name indicates, the pen assembly is free to move up and down and to rotate around the main shaft. When using this instrument, hold the pen in the raised position, adjust the setscrew to give the desired radius, and then gently lower the pen to the paper surface and draw the circle by rotating the pen around the shaft.

Maintenance of Compasses and Dividers

Figure 2-17 shows the three shapes in which compasses and dividers are made: round, flat, and bevel. Figure 2-18 shows two types of pivot joints commonly found on compasses and dividers. When you select compasses and dividers, test them for alignment by bending the joints and bringing the points together. New instruments are factory adjusted for correct friction setting. They rarely require adjustment. A small jeweler's screwdriver or the screwdriver found in some instrument sets (fig. 2-15H) is used for adjusting most pivot joint instruments. Instruments that require a special tool should be adjusted by skilled instrument repairmen.

Pivot joint compasses and dividers should be adjusted so that they may be set without undue friction. They should not be so rigid that their manipulation is difficult, nor so loose that they will not retain their setting.



Courtesy of Keuffel & Esser Company, Rockaway, NJ

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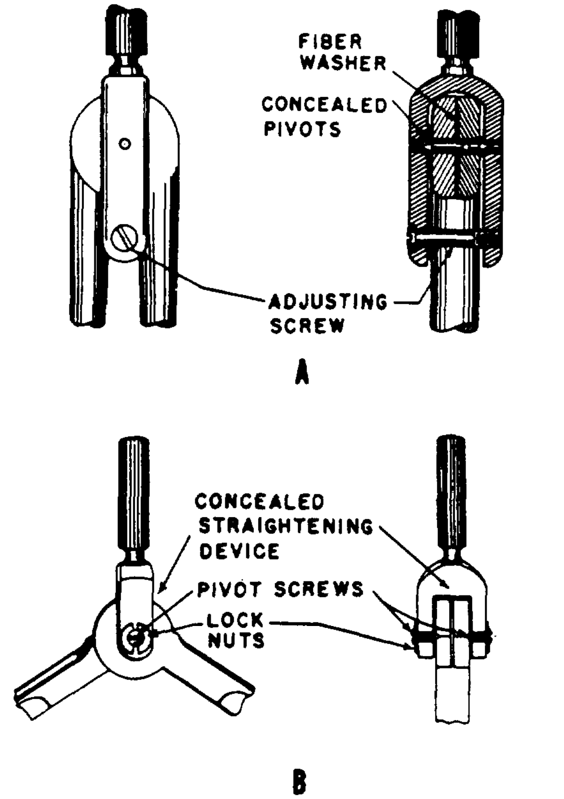
Figure 2-17.-Shapes of compasses and dividers: (A) Round; (B) Flat; (C) Bevel.



Courtesy of Keuffel & Esser Company, Rockaway, NJ

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Figure 2-18.-Sections of pivot joints.

Divider points should be straight and free from burrs. When the dividers are not in use, the points may be protected by sticking them into a small piece of soft rubber eraser or cork. When points become dull or minutely uneven in length, make them even by holding the dividers vertically, placing the legs together, and grinding them lightly back and forth against a whetstone. (See fig. 2-19, view A.) Then hold the dividers horizontally and sharpen each point by whetting the outside of it back and forth on the stone, while rolling it from side to side with your fingers (fig. 2-19, view B). The inside of the leg should remain flat and should not be ground on the stone. The outside of the point should not be ground so that a flat surface results. In shaping the point, be careful to avoid shortening the leg.

Needles on compasses and dividers should be kept sharpened to a fine taper. When they are pushed into the drawing, they should leave a small, round hole in the paper no larger than a

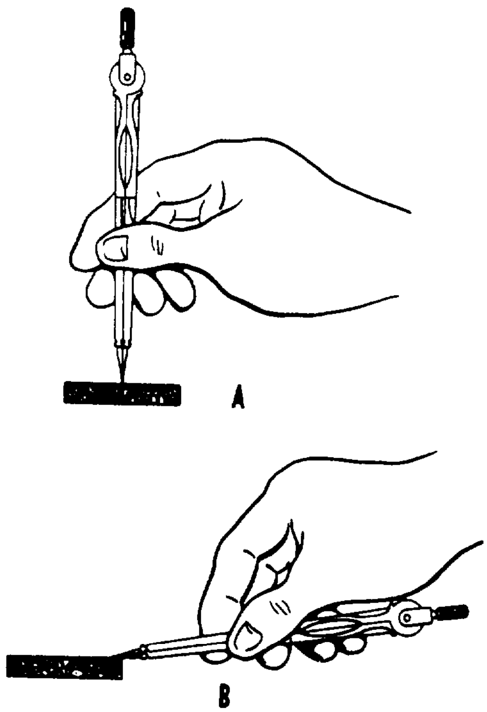

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Figure 2-19.-Divider maintenance: (A) Evening the legs of dividers; (B) Sharpening divider needlepoints.

pinhole. Since the same center is often used for both the compasses and dividers, it is best that needles on both be the same size. If the compass needle is noticeably larger, grind it until it is the correct size.

To make a compass needle smaller, wet one side of the whetstone and place the needle with its shoulder against this edge. Then grind it against the whetstone, twirling it between your thumb and forefinger (fig. 2-20). Test it for size by inserting it in a hole made by another needle of the correct size. When it is pushed as far as the shoulder, it should not enlarge the hole.

The screw threads on bow instruments are delicate. Because of this, you should take care never to force the adjusting nut. Threads must be kept free from rust or dirt.

If possible, it is best to keep drawing instruments in a case, since the case protects them from damage from falls or unnecessary pressures. Then, too, the lining of the case is usually treated with a chemical that helps prevent the instruments from tarnishing or corroding.

To protect instruments from rusting when they are not in use, clean them frequently with a soft cloth and apply a light film of oil to their surface

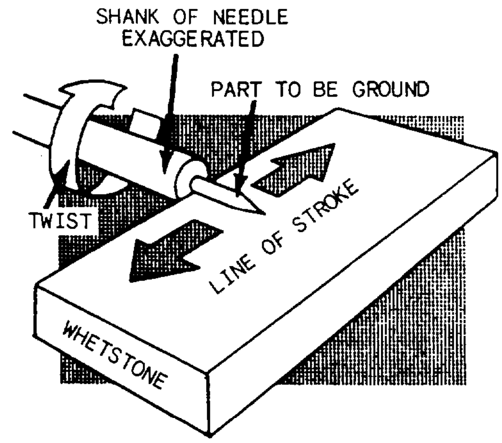

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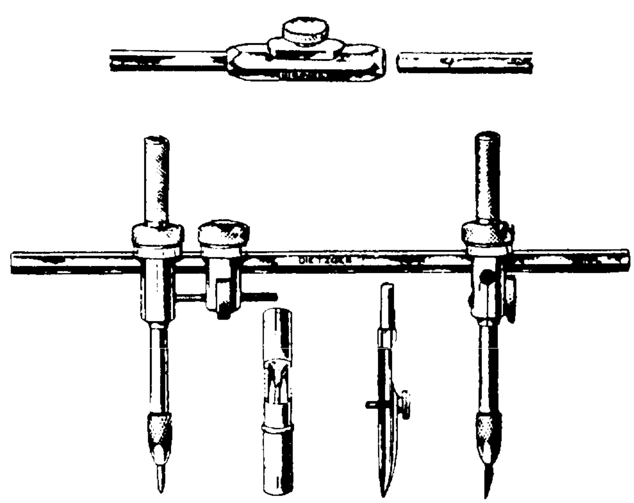
Figure 2-20.-Shaping a compass needle.

with a rag. Joints on compasses and dividers should not be oiled. When the surface finish of instruments becomes worn or scarred, it is subject to corrosion; therefore, a knife edge or an abrasive should never be used to clean drafting instruments.

Beam Compass

The BEAM COMPASS (fig. 2-21) is used for drawing circles with radii larger than can be set on a pivot joint or bow compass. Both the needlepoint attachment and the pen or pencil attachment on a beam compass are slide-mounted on a metal



Courtesy of Dietzgen Corporation

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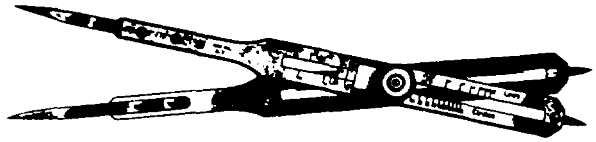
Figure 2-21.-Beam compass.



Courtesy of Keuffel & Esser Company, Rockaway, NJ

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Figure 2-22.-Proportional dividers.

bar called a beam. The slide-mounted attachments can be locked in any desired position on the beam. Thus, a beam compass can be used to draw circles of any radius up to the length of the beam. With one or more beam extensions, the length of the radius of a beam compass ranges from about 18 in. to 70 in.

PROPORTIONAL DIVIDERS

PROPORTIONAL DIVIDERS (fig. 2-22) are used for transferring measurements from one scale to another. This capability is necessary when drawings are to be made to a larger or smaller scale. They can also be used to divide lines or circles into equal parts.

Proportional dividers consist of two legs of equal length, pointed at each end, and held together by a movable pivot. By varying the position of the pivot, you can adjust the lengths of the legs on opposite sides of the pivot so that the ratio between them is equal to the ratio between two scales. Therefore, a distance spanned by the points of one set of legs has the same relation to the distance spanned by the points of the other set as one scale has to the other.

On the proportional dividers, a thumb nut moves the pivot in a rack-and-gear arrangement. When the desired setting is reached, a thumb-nut clamp on the opposite side of the instrument locks the pivot in place. A scale and vernier are provided on one leg to facilitate accurate setting. On less expensive models, the movable pivot is not on a rack and gear, and there is no vernier. The dividers may be set by reference to the table of settings that is furnished with each pair; they will accommodate varying ranges of scales from 1:1 to 1:10. However, it is better not to depend entirely on the table of settings. You can check the adjustment by drawing lines representing the desired proportionate lengths, and then applying the points of the instrument to them in turn until, by trial and error, the correct adjustment is reached.

To divide a line into equal parts, set the divider to a ratio of 1 to the number of parts desired on the scale marked Lines. For instance, to divide a line into three parts, set the scale at 3. Measure off the length with points of the longer end. The span of the points at the opposite ends will be equal to one-third the measured length. To use proportional dividers to transfer measurements from feet to meters, draw a line 1 unit long and another line 3.28 units long and set the dividers by trial and error accordingly.

Some proportional dividers have an extra scale for use in getting circular proportions. The scale marked Circle indicates the setting for dividing the circumference into equal parts.

The points of the dividers are of hardened steel, and if they are handled carefully, these points will retain their sharpness during long use. If they are damaged, they may be sharpened and the table of settings will still be usable, but the scale on the instrument will no longer be accurate.

SCALES

In one sense, the term scale means the succession of graduations on any graduated standard of linear measurement, such as the graduations on a steel tape or a thermometer. In another sense, when we refer to the “scale of a drawing,” the term means the ratio between the dimensions of the graphic representation of an object and the corresponding dimensions of the object itself.

Suppose, for example, that the top of a rectangular box measures 6 in. by 12 in. If you draw a 6-in. by 12-in. rectangle on the paper, the dimensions of the drawing would be the same as those of the object. The drawing would, therefore, be a full-scale drawing. This scale could be expressed fractionally as 1/1, or it could be given as 1 in. = 1 in.

Suppose that instead of making a full-scale drawing, you decided to make a half-scale drawing. You should then draw a 3-in. by 6-in. rectangle on the paper. This scale could be expressed fractionally as 1/2, or it could be given as 1 in. = 2 in., or as 6 in. = 1 ft.

In this case, you made a drawing on a smaller scale than the scale of the original object, the scale of an original object being always 1/1, or unity. The relative size of a scale is indicated by the fractional representation of the scale. A scale whose fractional representation equals less than unity is a less-than-full scale. One whose fractional representation is greater than unity (such as a scale of 200/1) is a larger-than-full scale. A scale of 1/10,000 is, of course, smaller than a scale of 1/100.

A scale expressed as an equation can always be expressed as a fraction. For example, the scale of 1 in. = 100 ft, expressed fractionally, comes to 1 over (100 x 12), or 1/1,200.

It is obvious that any object that is larger than the drawing paper on which it is to be represented must be “scaled down” (that is, reduced to less-than-full scale) for graphic representation. Conversely, it is often desirable to represent a very small object on a scale larger than full scale for the purpose of clarity and to show small details. Because the drawings prepared by an EA frequently require scaling down, the following discussion refers mostly to that procedure. However, scaling up rather than down simply means selecting a larger-than-full scale rather than a smaller-than-full scale for your drawing.

You could, if necessary, determine the dimensions of your drawing by arithmetical calculation; for example, on a half-scale drawing, you divide each of the actual dimensions of the object by 2. However, this might be a time-consuming process if you were drawing a map of a certain area to a scale of 1 in. = 1,000 mi, or 1/6,335,000 ft.

Consequently, you will usually scale a drawing up or down by the use of one or another of a variety of scales. This sense of the term scales refers to a graduated, rulerlike instrument on which scale dimensions for a drawing can be determined by inspection.

Scales vary in types of material, shapes, style of division, and scale graduations. Good quality scales are made of high-grade boxwood or plastic, while inexpensive scales are sometimes made of

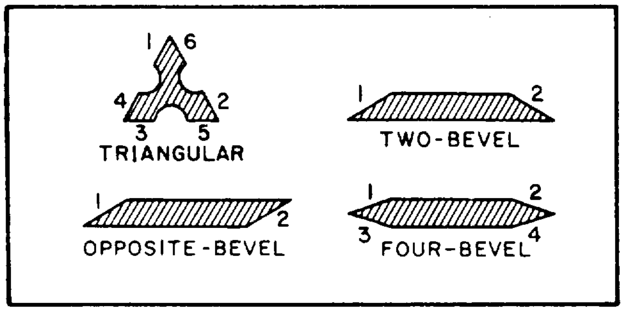

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Figure 2-23.-Types of scales in cross section.

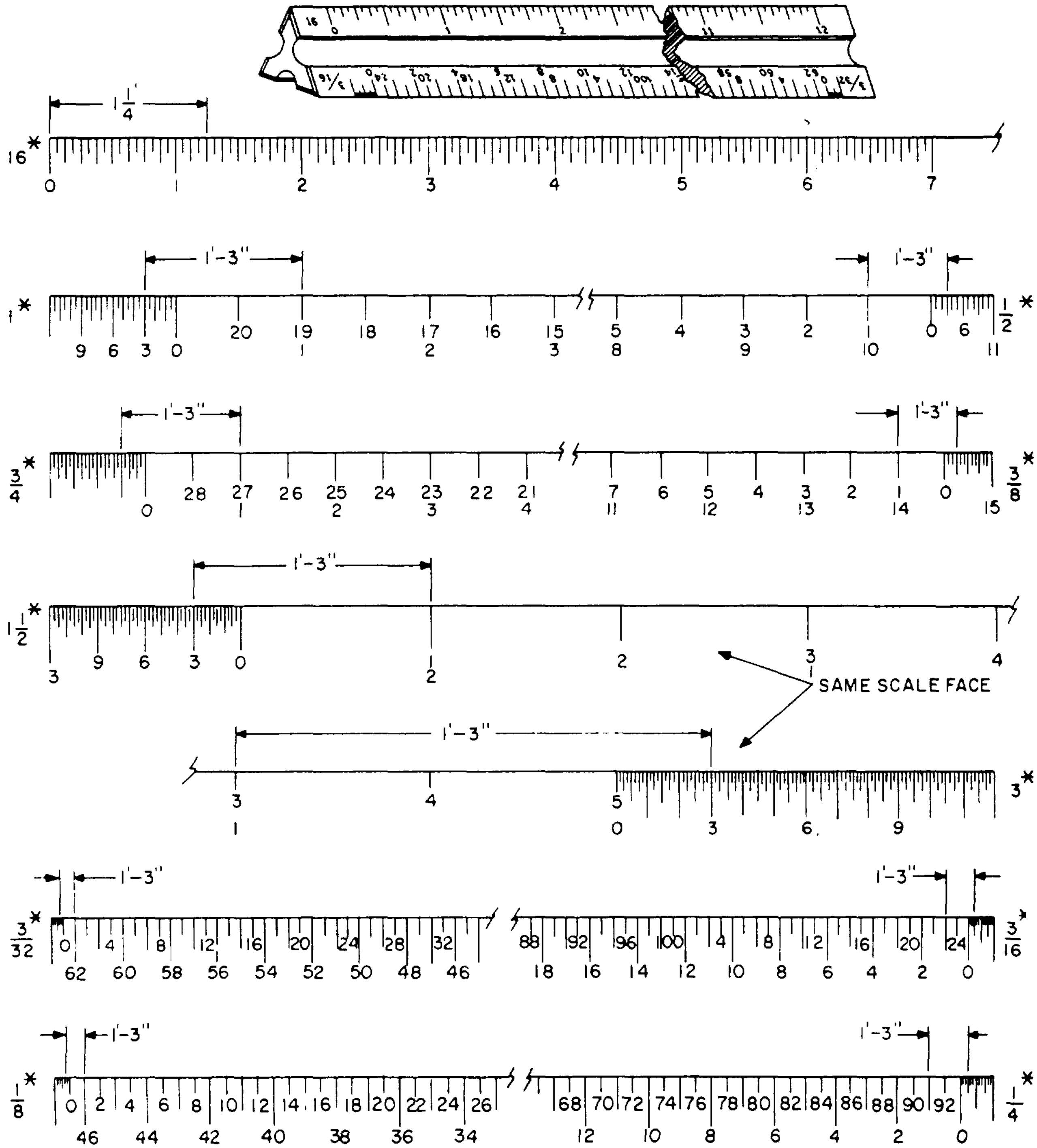
yellow hardwood. The boxwood scales have white plastic scale faces that are permanently bonded to the boxwood. The graduation lines on the boxwood scales are cut by a highly accurate machine. Plastic scales, while less expensive than boxwood scales, have clear graduations and are reasonably accurate.

Scales are generally available in four different shapes, as shown in figure 2-23. The numbers in the figure indicate the location of the scale face. The triangular scale provides six scale faces on one rule. The two-bevel flat scale provides two scale faces on one side of the rule only. The opposite-bevel flat scale provides two scale faces, one on each side of the rule. And the four-bevel flat scale provides four scale faces, two on each side of the rule. The most common types of scales are the architect’s, the engineer’s, the mechanical engineer’s, and the metric. All of these scales are found in the EA’s draftsman kit with the exception of the mechanical engineer’s scale, which is primarily used by machine draftsmen.

To gain a better understanding of the architect’s and engineer’s scale, which will be described in the following sections, it may be helpful to have the actual scales at hand as you study.

Architect’s Scale

ARCHITECT’S SCALES are usually triangular in shape and are used wherever dimensions are measured in feet and inches. Major divisions on the scale represent feet which, in turn, are subdivided into 12ths or 16ths, depending on the individual scale.



NOTE:
16 SCALE IS SUBDIVIDED INTO SIXTEENTHS.
ALL OTHERS ARE SUBDIVIDED INTO TWELFTHS.
* SCALE DESIGNATION NUMBERS.

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Figure 2-24.-Architect's scale.

Figure 2-24 shows the triangular architect's scale. Also shown are segments of each of the eleven scales found on this particular type of scale. Notice that all scales except the 16th scale are actually two scales that read from either left to right or right to left. When reading a scale numbered from left to right, notice that the numerals are located closer to the outside edge. On scales that are numbered from right to left, notice that the numerals are located closer to the inside edge.

Architect's scales are "open" divided (only the main divisions are marked throughout the length) with the only subdivided interval being an extra interval below the 0-ft mark. These extra intervals are divided into 12ths. To make a scale measurement in feet and inches, lay off the number of feet on the main scale and add the inches on the subdivided extra interval. However, notice that the 16th scale is fully divided with its divisions being divided into 16ths.

Now let's measure off a distance of 1 ft 3 in. to see how each scale is read and how the scales compare to one another. (Refer to fig. 2-24.) Since the graduations on the 16th scale are subdivided into 16ths, we will have to figure out that 3 in. actually is 3/12 or 1/4 of a foot. Changing this to 16ths, we now see we must measure off 4/16ths to equal the 3-in. measurement. Note carefully the value of the graduations on the extra interval, which varies with different scales. On the 3 in. = 1 ft scale, for example, the space between adjacent graduations represents one-eighth in. On the 3/32 in. = 1 ft scale, however, each space between adjacent graduations represents 2 in.

The scale 3/32 in. = 1 ft, expressed fractionally, comes to 3/32 = 12, or 1/128. This is the smallest scale provided on an architect's scale. The scales on the architect's scale, with their fractional equivalents, are as follows:

3 in. = 1 ft . . . . 1/4 scale

1 1/2 in. = 1 ft . . . . 1/8 scale

1 in. = 1 ft . . . . 1/12 scale

3/4 in. = 1 ft . . . . 1/16 scale

1/2 in. = 1 ft . . . . 1/24 scale

3/8 in. = 1 ft . . . . 1/32 scale

1/4 in. = 1 ft . . . . 1/48 scale

1/16 in. = 1 ft . . . . 1/64 scale

1/8 in. = 1 ft . . . . 1/96 scale

3/32 in. = 1 ft . . . . 1/128 scale

Engineer's Scale

The chain, or civil engineer's, scale, commonly referred to as the ENGINEER'S SCALE, is usually a triangular scale, containing six fully divided scales that are subdivided decimally, each major interval on a scale being subdivided into 10ths. Figure 2-25 shows the engineer's scale and

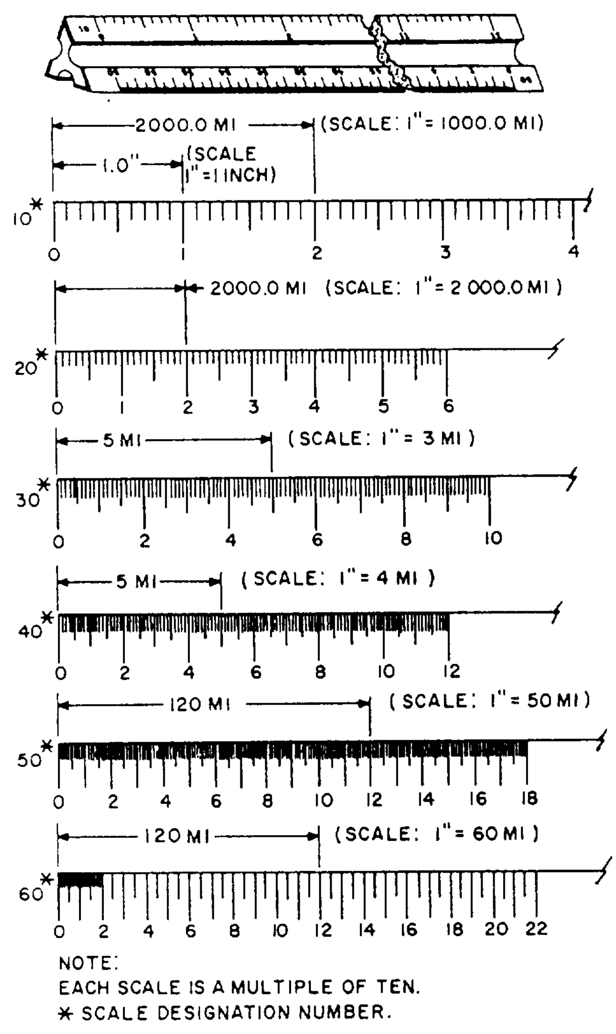

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Figure 2-25.-Engineer's scale.

segments of each of the six scales. Each of the six scales is designated by a number representing the number of graduations that particular scale has to the linear inch. On the 10 scale, for example, there are 10 graduations to the inch; on the 50 scale there are 50. You can see that the 50 scale has 50 graduations in the same space occupied by 10 on the 10 scale. This space is 1 linear inch.

To determine the actual number of graduations represented by a numeral on the engineer's scale, multiply the numeral by 10. On the 50 scale, for instance, the numeral 2 indicates 2 x 10, or 20 graduations from the 0. On the 10 scale, the numeral 11 indicates 11 x 10, or 110 graduations from the 0. Note that the 10 scale is numbered every major graduation, while the 50 scale is numbered every other graduation. Other scales on the engineer's scale are the 20, 30, 40, and 60.

Because it is decimally divided, the engineer's scale can be used to scale dimensions down to any scale in which the first figure in the ratio is 1 in. and the other is 10, or a multiple of 10.

Suppose, for example, that you wanted to scale a dimension of 150 mi down to a scale of 1 in. = 60 mi. You would use the 60 scale, allowing the interval between adjacent graduations to represent 1 mi. To measure off 150 mi to scale on the 60 scale, you would measure off 2.5 in., which falls on the 15th major graduation.

Suppose now that you want to scale a dimension of 6,500 ft down to a scale of 1 in. = 1,000 ft. The second figure in the ratio is a multiple of 10 times a multiple of 10. You would therefore use the 10 scale, allowing the interval between adjacent graduations on the scale to represent 100 ft, in which case the interval between adjacent numerals on the scale would indicate 1,000 ft. To measure off 6,500 ft, you would simply lay off from 0 to 6.5 on the scale.

To use the engineer's scale for scaling to scales that are expressed fractionally, you must be able to determine the fractional equivalent of each of the scales. For any scale, this equivalent is simply 1 over the total number of graduations on the scale, or 1 over the product of the scale number times 12, which comes to the same thing. Applying this rule, the fractional expressions of each of the scales is as follows:

10 scale = 1/120

20 scale = 1/240

30 scale = 1/360

40 scale = 1/480

50 scale = 1/600

60 scale = 1/720

Suppose you wanted to scale 50 ft down to a scale of 1/120. The 10 scale gives you this scale; you would therefore use the 10 scale, allowing the space between graduations to represent 1 ft, and measuring off 5 (for 50 ft). The line on your paper would be 5 in. long, representing a line on the object itself that is 120 in. x 5 in., or 600 in., or 50 ft long.

Similarly, if you wanted to scale 50 ft down to a scale of 1/600, you would use the 50 scale and measure off 5 for 50 ft. In this case, the line on your paper would be 1 in. long, representing a line on the object itself that is 1 x 600, or 600 in., or 50 ft long.

When it is not required that the drawing be made to a specified scale—that is, when the dimensions of lines on the drawing are not required to bear a specified ratio to the dimensions of lines on the object itself—the most convenient scale on the engineer's scale is used. Suppose, for example, that you want to draw the outline of a 360-ft by 800-ft rectangular field on an 8-in, by 10 1/2-in. sheet of paper with no specific scale prescribed. All you want to do is reduce the representation of the object to one that will fit the dimensions of the paper. You could use the 10 scale, allowing the interval between adjacent graduations to represent 10 ft. In this case, the numerals on the scale, instead of representing 10, 20, and so on, will represent 100, 200, and so on. To measure off 360 ft to scale, you should measure from 0 to the 6th graduation beyond the numeral 3. For 800 ft you should measure from 0 to the numeral 8.

Because you allowed the interval between adjacent graduations to represent 10 ft, and because the 10 scale has 10 graduations to the in., the scale of your drawing would be 1 in. = 100 ft, or 1/1,200.

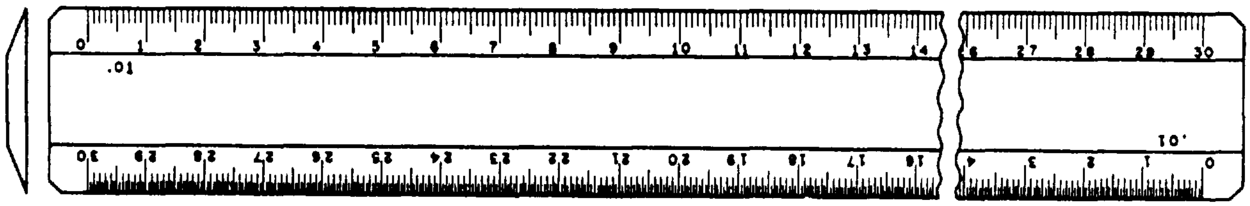

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Figure 2-26.-Flat metric scale.

Metric Scale

The METRIC SCALE is used in the place of the architect's and the engineer's scale when measurements and dimensions are in meters and centimeters. Metric scales are available in flat and triangular shapes. The flat 30-cm metric scale is shown in figure 2-26. The top scale is calibrated in millimeters and the bottom scale in half millimeters. The triangular metric scale has six fully divided scales, which are 1:20, 1:33 1/3, 1:40, 1:50, 1:80, and 1:100.

When you are using scales on a drawing, do not confuse the engineer's scale with the metric scale. They are very similar in appearance. Whenever conversions are made between the metric and English system, remember that 2.54 cm equals 1 in.

Triangular Scale Clip

For use with a triangular scale, a scale clip or scale guard, such as the one shown in figure 2-27, is very helpful. The clip makes it easy for you to identify what scale you are using. Large spring-type paper clips will serve the same purpose when scale clips are not available.

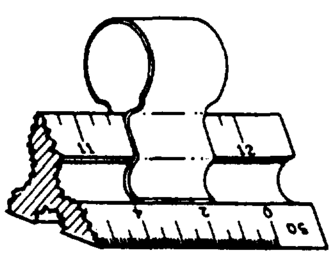

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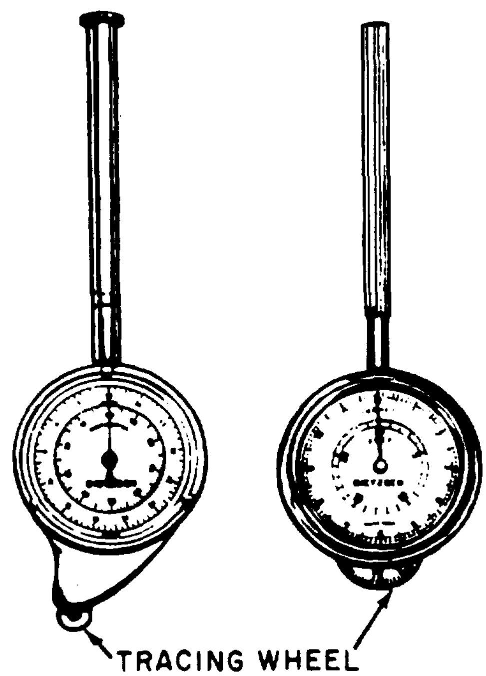
Figure 2-27.-Use of triangular scale clip.

MAP MEASURES AND SCALE INDICATORS

MAP MEASURES are precision instruments for measuring the lengths of roads, pipelines, and other irregular outlines on maps and drawings. Distances are measured by first setting the instrument to zero, then tracing the line to be measured with the small, projecting tracing wheel, like that on the map measures shown in figure 2-28.

In using map measures, do not depend entirely on the indicated numerical scale. Always check it against the graphical scale on the map or drawing. Verify if, for example, 1 in. traversed



Courtesy of Dietzgen Corporation

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Figure 2-28.-Types of map measures.

on the graphical scale really registers 1 in. on the dial; if not, make the proper correction to the distance measured. Actually, a map measure is just another odometer. Odometers are used to measure actual distances, while the map measures are used to measure scaled distances.

There are many ways of indicating the scale on a drawing. Among these are the fractional method, the equation method, and the graphic method.

In the fractional method, the scale is indicated as a fraction or a ratio. A full-size scale is indicated as 1/1; enlarged scale, as 10/1, 4/1, 2/1, etc.; and reduced scale, as 1/2, 1/4, 1/10, etc. Notice that the drawing unit is always given as the numerator of the fraction and the object unit as the denominator. On maps, the reduced scale fraction may be very large (for example, 1/50,000), as compared with the typical scales on machine drawings. On maps, the scale is frequently expressed as a ratio, such as 1:50,000.

In the equation method, a certain number of inches on the drawing is set equal to a certain length on the object. Symbols are used for feet (') and inches ("). On architectural drawings, a certain number of inches on the drawing is set to equal to 1 foot on the object. A full-size scale is entered as 12" = 1' – 0"; an enlarged scale, as 24" = 1'–0"; and a reduced scale, as 1/8" = 1' – 0". On civil engineering drawings, 1 in. on the drawing is set to equal to a certain measurement on the object: 1" = 5', 1" = 100', 1" = 1 mi.

In the graphic method, an actual measuring scale is shown on the drawing. Typical graphic scales are shown in figure 2-29. Note that in each case, the primary scale lies to the **right** of the 0; a subdivided primary scale unit lies to the **left** of the 0.

DRAFTING TEMPLATES

DRAFTING TEMPLATES are timesaving devices that are used for drawing various shapes and standard symbols. They are especially useful when shapes and symbols must appear on the drawing a number of times. Templates are usually made of transparent green or clear plastic. They are available in a wide variety of shapes, including circles, ellipses, hexagons, triangles, rectangles, and arcs. Special templates are available for symbols used on architectural drawings, mechanical drawings, and maps. Templates for almost every purpose are available from the well-known drafting supply companies. Figure 2-30 shows only a few of the more common types of drafting templates. One set of commonly used drafting templates is included in the EA's draftsman kit.

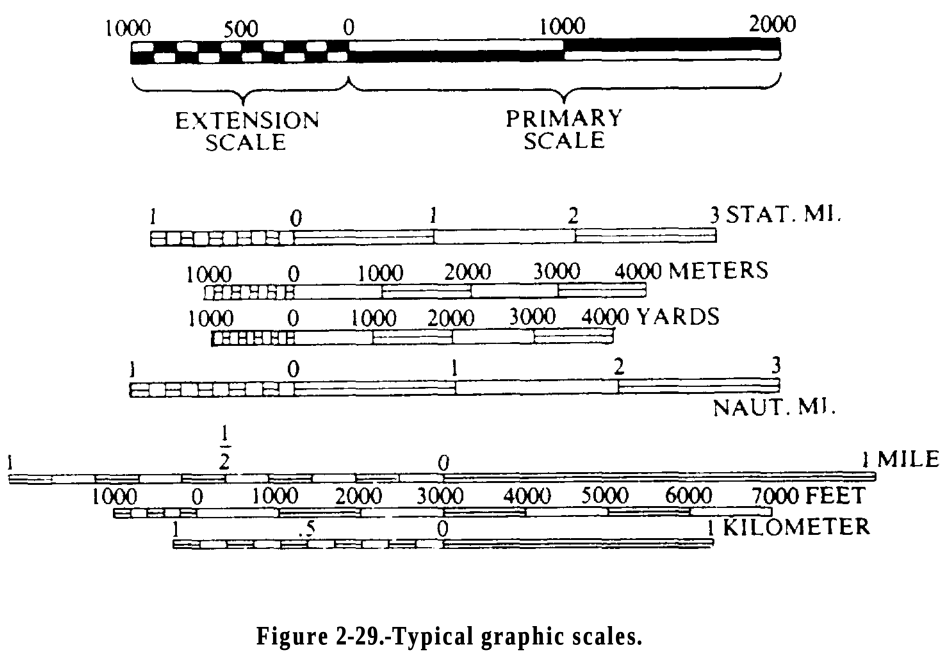

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Figure 2-29.-Typical graphic scales.

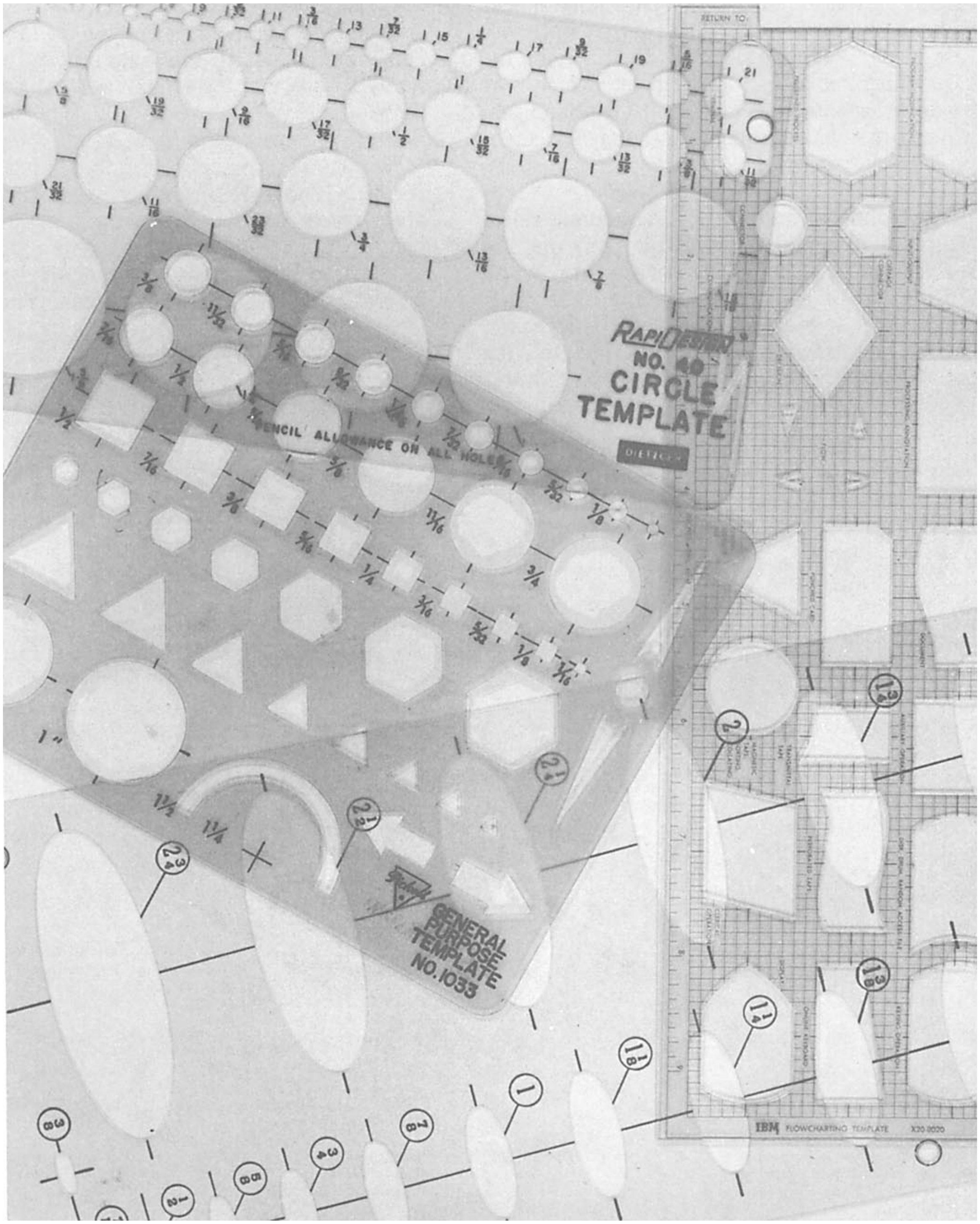

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Figure 2-30.—Drafting templates.

FREEHAND LETTERING PENS

Frequently, you will prepare inked drawings, maps, or charts that require freehand lines and lettering. There are many types of freehand pens available. But here we will be concerned only with those pens used by the EA. Included in the draftsman kit is a reservoir pen set, which may be used either with a penholder, as a freehand pen, or fitted into a mechanical lettering device for template lettering.

The technical fountain pen (sometimes called a Rapidograph pen or reservoir pen) may be used for ruling straight lines of uniform width with the aid of a T square, triangle, or other straightedge. It may also be used for freehand lettering and drawing and with various drawing and lettering templates. One of the best features of the technical fountain pen is its ink reservoir. The reservoir, depending on the style of pen, is either built into the barrel of the pen or is a translucent plastic ink cartridge attached to the body of the pen. The large ink capacity of the reservoir saves time because you do not have to constantly replenish the ink supply. Therefore, many EAs prefer the technical fountain pen to the ruling pen.

A typical technical fountain pen is shown in figure 2-31. Variations in pen style and line size are offered from various manufacturers. Some pens are labeled by the metric system according to the line weight they make. Other pens are labeled with a code that indicates line width measured in inches. For instance, a No. 2 pen draws a line .026 in. in width. Most technical fountain pens are color-coded for easy

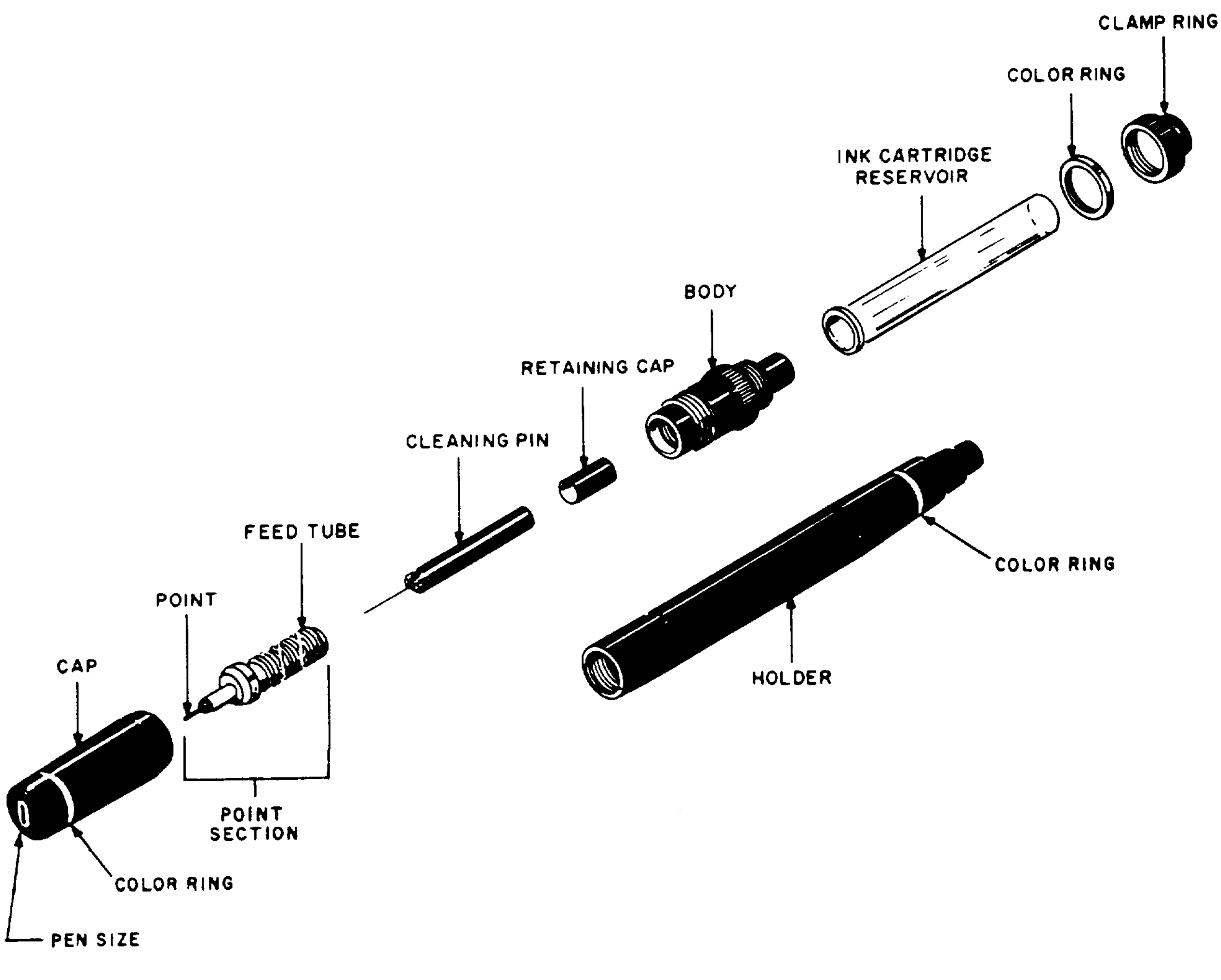

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Figure 2-31.-Technical fountain pen.

identification of pen size. These pens are available either as individual fountain pen units, resembling a typical fountain pen, or as a set, having a common handle and interchangeable pen units. The pen shown in figure 2-31 is a part of a set of technical fountain pens.

Some reservoir pens for lettering are made so the point section will fit in a Leroy scriber. (The Leroy letter set will be discussed in chapter 3.) These pens may also be used for any work that a regular technical fountain pen is used for.

Processes of Using the Technical Fountain Pen

As shown in figure 2-32, you must hold the technical fountain pen so that it is perpendicular to the drawing surface at all times. If you don't hold the pen in the correct manner, the point will bevel or wear unevenly and eventually form an elliptical point. With the point in this condition, the pen will produce lines of inconsistent widths.

To fill the reservoir of a fountain pen, use the knob located on the barrel opposite the point. When you turn the knob counterclockwise, a plunger is forced down into the barrel forcing out any ink remaining in the reservoir. Place the point end of the pen into the ink and turn the knob clockwise to pull the plunger up. As the plunger is pulled up, ink is drawn through the point, filling the reservoir.

To fill the ink cartridge type of pen shown in figure 2-31, remove the cartridge from the body and insert the ink bottle dropper all the way into the reservoir cartridge. Place the dropper in contact with the bottom of the reservoir cartridge to prevent the ink from forming air bubbles. Fill the cartridge to approximately three-eighths of an inch from the top, then replace the cartridge and clamp ring.

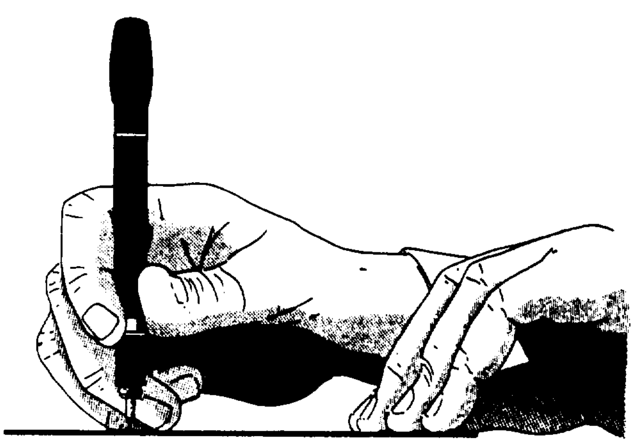

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Figure 2-32.-Drawing with a technical fountain pen.

Care and Cleaning of the Technical Fountain Pen

The feed tube of the pen point is threaded (fig. 2-3 1). Along this threaded portion is an inclined channel that allows air to enter the ink reservoir. This channel must be free of dried ink or foreign particles to ensure correct ink flow. When cleaning the pen, scrub the threads and channel with a brush, such as a toothbrush, wetted with a cleaning solution of soap and water. A cleaning pin (a tiny weighted needle) is made so that it fits into the feed tube and point (fig, 2-31). This cleaning pin assures a clear passage of ink from the reservoir to the point. Usually, a light shake of the pen will set the cleaning pin in motion, removing any particles that settle in the tube when not in use. (Do not shake the pen over your drawing board.)

If the pen is not used frequently, the ink will dry, clogging the point and feed tube. When the pen becomes clogged, soak the pen in pen cleaner or ammonia water until it will unscrew with little or no resistance. A better practice is to clean the pen before you put it away if you know in advance that you will not be using it for several days.

The cleaning pin must be handled with care, especially the smaller sizes. A bent or damaged cleaning pin will never fit properly into the feed tube and point.

DRAWING INK

A draftsman's drawing ink is commonly called INDIA INK. Drawing ink consists of a pigment (usually powdered carbon) suspended in an ammonia-water solution. Ink that has thickened by age or evaporation maybe thinned slightly by adding a few drops of solution of four parts aqua ammonia to one part distilled water. After the ink dries on paper, it is waterproof. Drawing ink is available in many different colors, but for construction and engineering drawings, black ink is preferred for reproduction and clarity. Small

3/4- or 1-oz bottles of black, red, and green ink are found in the standard draftsman kit. Larger bottles are available for refilling the small bottles. The stopper for a small ink bottle is equipped with either a squeeze dropper or a curved pipette for filling pens.

When you are working with ink, always keep the stopper on the ink bottle when you are not filling the pen, and keep the bottle far away from your drawing. Nothing is more frustrating for a draftsman than to spill a bottle of ink on a finished drawing. Special bottle holders are available to minimize this hazard. If you do not have a bottle holder, it would be to your advantage to devise your own.

OTHER TOOLS

Many tools other than the ones already presented in this chapter are currently used to help create technical drawings. A variety of drafting machines (not in the draftsman kit) are available at several shore-based support activities. Dependent upon the requirements of that particular activity, an EA assigned to staff or independent duty may also be exposed to a more advanced and sophisticated computer-assisted drafting method.

The standard drafting machine combines the functions of a parallel ruler, protractor, scales, and triangles. Various drafting operations requiring straight and parallel lines may be performed advantageously with a drafting machine.

The majority of drafting machines are constructed so that the protractor head may be moved over the surface of a drafting table without change in orientation by means of a parallel-motion linkage consisting of two sets of double bars. Figure 2-33 shows a rigid metal connecting link or arms, commonly called pin-joint linkage.

Another type of drafting machine has two steel bands enclosed in tubes working against one another (fig. 2-34) (although this type may also

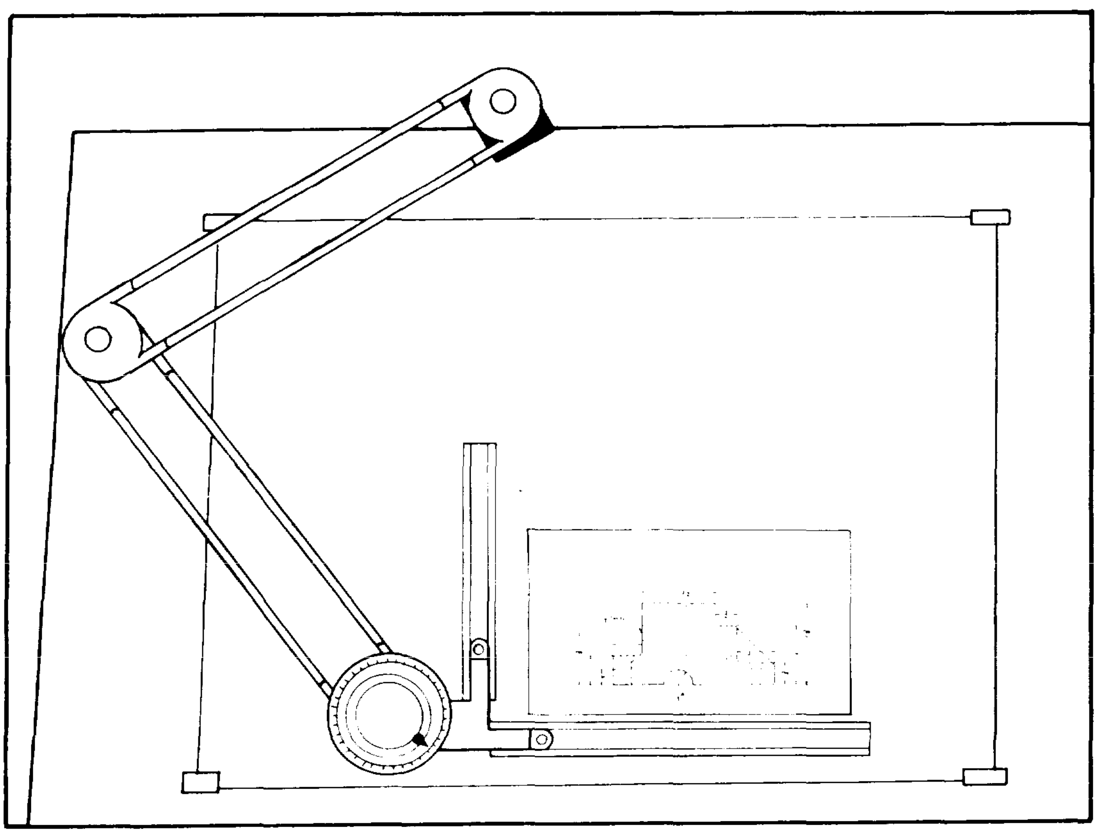

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Figure 2-33.-Drafting machine with rigid arms.

have the bands without the tubes). If these bands become loose through wear or expansion, the tension can be increased on them. This type of drafting machine is superior to that with pin-point linkage because there is less lost motion.

To learn more about other tools and their uses, refer to chapter 1 of the field manual FM 5-553, General Drafting, published by the Headquarters, Department of the Army, and other civilian publications.

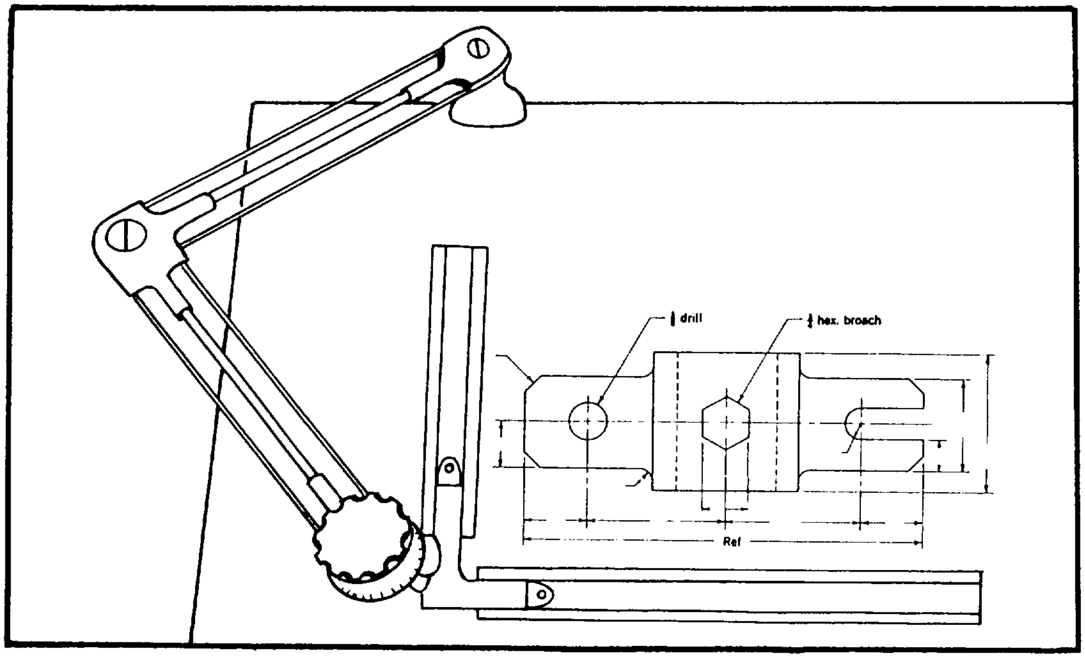

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Figure 2-34.-Drafting machine with enclosed steel bands.